Measurement of Light Mesons by the PHENIX Experiment at RHIC

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Abstract. The PHENIX experiment at RHIC has measured various light mesons using multiple decay channels over a wide range of transverse momentum. In these proceedings, we present a review of the most recent results on the production of ω, ϕ, K^*, K_s in p+p collisions and their nuclear modification factors in d+Au , Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. Results of ϕ production at $\sqrt{s_{NN}} = 62.4$ GeV are also discussed.

1. Introduction

One of the interesting findings at RHIC is the yield suppression of high p_T mesons in ultra relativistic heavy-ion collisions, compared to the expectations from scaled p+p results [1, 2]. This is attributed to the medium effects induced by the hot and dense matter created in these collisions, which in general are quantified in terms of the nuclear modification factor:

$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T dy}{(\langle N_{coll}\rangle/\sigma_{pp}^{inel}) \cdot d^2\sigma^{pp}/dp_T dy} \quad (1)$$

where $d^2N_{AA}/dp_T dy$ is the differential yield per event in nucleus-nucleus collisions, $\langle N_{coll}\rangle$ is the average number of inelastic binary nucleon-nucleon collisions for a given centrality, and σ_{pp}^{inel} and $d^2\sigma_{pp}/dydp_T$ are the total and differential cross-sections for inelastic p+p collisions. Comparison of the suppression of light mesons having different masses and quark content provides a very useful input to the overall understanding of the suppression mechanism. To have a complete interpretation of results in the heavy-ion collisions, one needs solid baseline p+p measurements and a clear picture of cold matter effects. The PHENIX experiment at RHIC has carried out systematic measurements of a variety of mesons via multi-particle decay channels. This paper reviews the most recent results on light mesons in p+p and heavy-ion collisions at different energies.

‡ A list of members of the PHENIX Collaboration can be found at the end of this issue.

2. ω, ϕ and K^* spectra in p+p and d+Au collisions

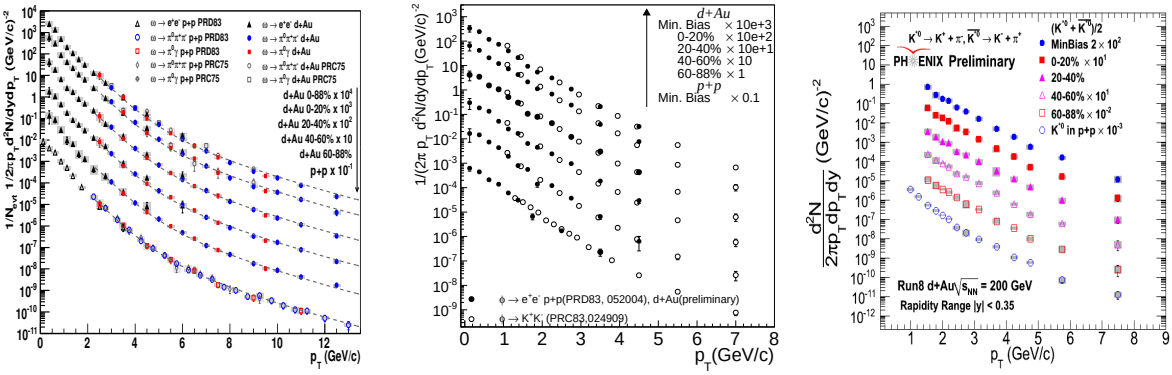

Figure 1. Left panel: $\omega \to e^+e^-$, $\omega \to \pi^0 K$, $\omega \to \pi^+\pi^0\pi^0$ spectra as measured in p+p and various centrality classes in d+Au collisions; Middle panel: the same for $\phi \to e^+e^-$, $\phi \to K^+K^-$; Right panel the same for $K^* \to \pi K$.

Fig. 1 shows a compilation of ω (left), ϕ (middle) and K^* (right) mesons' measurements in p+p and various centrality classes of d+Au collisions using different decay channels at $\sqrt{s_{NN}} = 200$ GeV. Different symbols for a given meson correspond to different decay channels. Good agreement can be seen between the measurements of a given meson using different decay channels; $\omega \to e^+e^-$ or $\omega \to \pi^0 K$ or $\omega \to \pi^+\pi^-\pi^0$, $\phi \to e^+e^-$ or $\phi \to K + K^-$. These new results cover the p_T range from 0.25 to 13 GeV/c for ω, 0 to 8 GeV/c for ϕ and 1-8 GeV/c for K^*. More details about the analysis for ω and ϕ, as well as transverse momentum spectra in Cu+Cu and Au+Au collisions can be found in [2] and [3, 4], respectively.

3. Nuclear modification factor at $\sqrt{s_{NN}} = 200$ GeV

Fig. 2 shows the nuclear modification factor R_{dAu} of ω and ϕ in central (0-20%), peripheral (60-88%) and minimum bias d+Au collisions, plotted together with π^0, η, η', K_s and p for comparison. The R_{dAu} of ω and ϕ follow the same pattern as that of π^0 and other mesons in all the centrality classes. For peripheral collisions, over the measured p_T range, R_{dAu} is consistent with unity. However, in the central collisions, a modest Cronin like enhancement can be seen over the p_T range from 2 GeV/c to 6 GeV/c, and a slight suppression at $p_T > 8$ GeV/c.

Fig. 3 shows the R_{AA} of ω, ϕ and K_s in the central (0-20%) Au+Au collisions. The R_{AA} of π^0, η, K, p, direct γ and $e^{\pm}_{HF}$ are also plotted in Fig. 3 for comparison. π^0 and η mesons follow the same suppression pattern over the entire p_T range, whereas protons are enhanced at $p_T \geq 1.5$ GeV/c. No suppression is seen for high p_T direct γ's [5]. The ϕ meson at intermediate p_T (2.5 GeV/c to 4.5 GeV/c) exhibits more suppression than the protons, but less suppression than η and π^0 mesons, whereas at higher p_T, within the large uncertainties, the amount of suppression appears the same as that of η and π^0.

Charged kaons and electrons from heavy flavor ($e^{\pm}_{HF}$) also seem to follow the same suppression pattern as that of ϕ. The measurements of ω and K_S cover the high p_T region (from 6 GeV/c to 14 GeV/c) and exhibit suppression similar to that of π^0 within the current precision. The fact that all the mesons show similar suppression at high p_T (>7 GeV/c) supports the production of these mesons via jet-fragmentation outside the hot and dense medium created in these collisions.

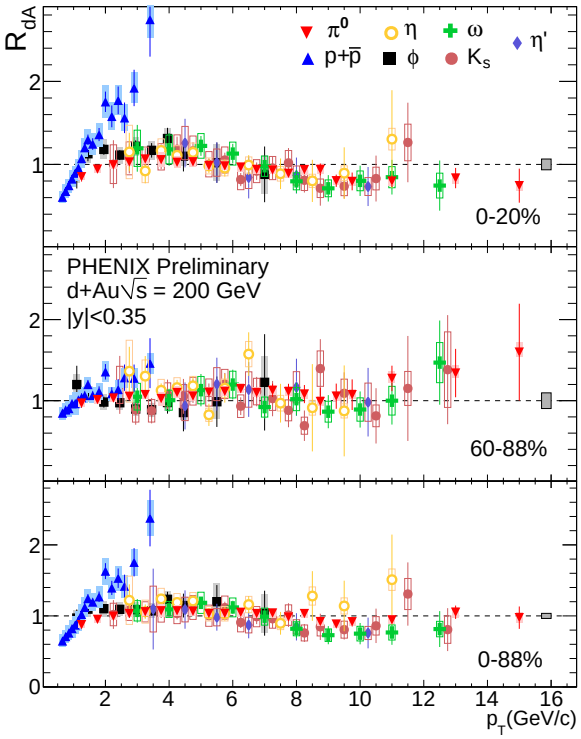

Figure 2. Nuclear modification factor R_{dAu} in d+Au collisions.

The nuclear modification factor of ω and ϕ in Cu+Cu collisions has also been measured and can be found elsewhere [3, 4]. The results show that for similar number of participating nucleons ($\langle N_{part} \rangle$) in Cu+Cu and Au+Au collisions, *i.e.* similar energy density, the amount of suppression is the same and this has been observed for other mesons also [6] and supports the fact that suppression is dependent on $\langle N_{part} \rangle$ only and is not so sensitive to the details of the collision geometry.

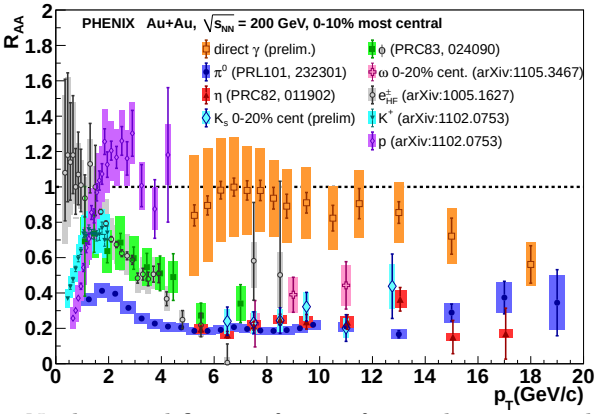

Figure 3. Nuclear modification factor of several mesons in the central (0-20%) Au+Au collisions.

4. Results at $\sqrt{s_{NN}} = 62.4$ GeV collisions

PHENIX has also measured the ϕ meson via its K^+K^- decay channel at $\sqrt{s_{NN}} = 62.4$ GeV. The left panel in Fig. 4 shows the measured spectra in p+p collisions and various centrality classes in Cu+Cu and Au+Au collisions. The right panel shows the nuclear modification factor of ϕ in the central Au+Au and Cu+Cu collisions, overlayed with

π^0 and $p + \bar{p}$ results. Within the current precision, ϕ does not show any suppression at $\sqrt{s_{NN}} = 62.4$ GeV, but exhibits the same feature as for 200 GeV results *i.e.* its R_{AA} lies between that of p and π^0. Similar to 200 GeV, the Cu+Cu and Au+Au results corresponding to the similar number of $\langle N_{part} \rangle$ show a similar suppression (not shown here).

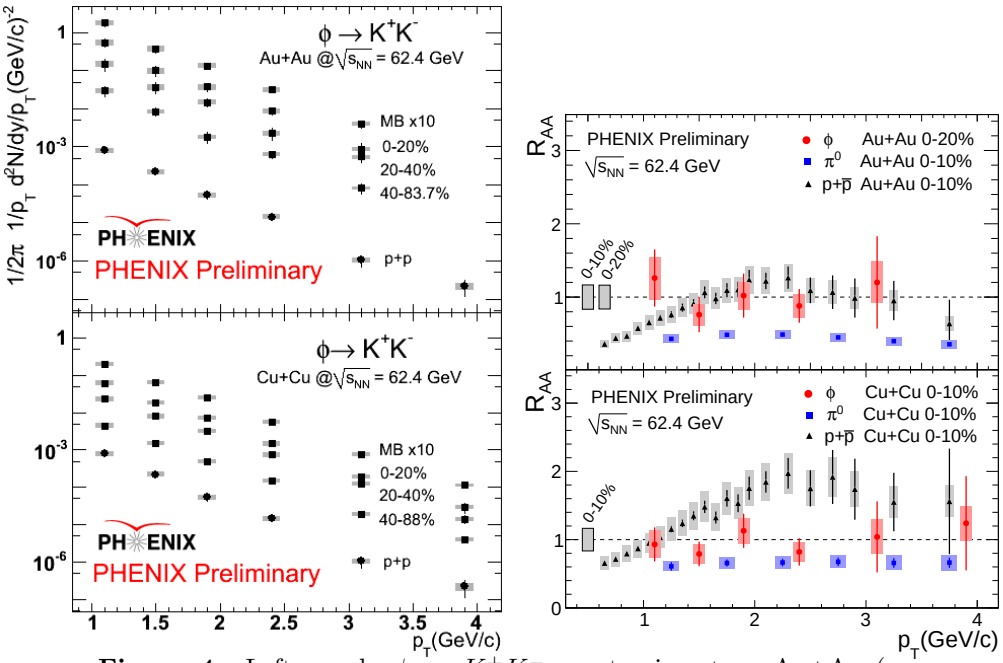

Figure 4. Left panel: $\phi \rightarrow K^+K^-$ spectra in p+p , Au+Au (upper panel) and Cu+Cu (lower panel) collisions; Right panel: R_{AA} in Au+Au and Cu+Cu collisions.

5. Summary

PHENIX has carried out a comprehensive study of light mesons at $\sqrt{s_{NN}} = 200$ GeV. Results indicate that in Au+Au collisions at 200 GeV, all mesons show similar suppression for $p_T > 7$ GeV/c, but exhibit differences at the intermediate p_T. At $\sqrt{s_{NN}} = 62.4$ GeV, ϕ meson does not show any suppression in Au+Au collisions, however similar to 200 GeV results, it lies between protons and pions.

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References

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